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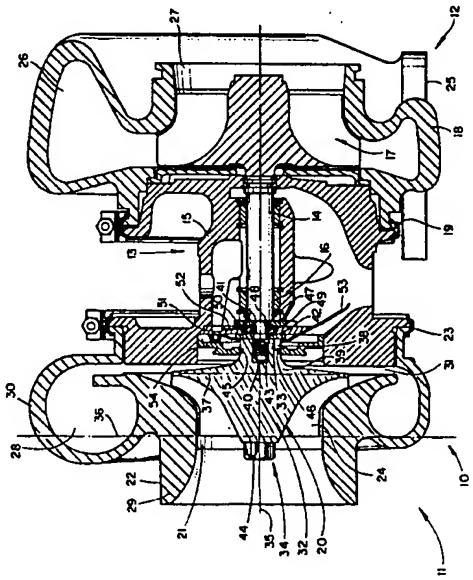
(54) Centrifugal compressor apparatus.

(57) A centrifugal compressor apparatus including a bearing housing rotatably receiving a shaft having an externally threaded end, a cover mounted to the bearing housing to define an impeller chamber, an impeller received within the chamber, the impeller including a hub which is solid in the area of the blades and having a boss extending therefrom which includes an internally-threaded bore within which the threaded end of the shaft is received.



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CENTRIFUGAL COMPRESSOR APPARATUS

Background of the Invention

Field of the Invention: The present invention relates to the field of centrifugal compressors, and more particularly to an improved design including a compressor wheel or impeller which has a solid hub for the axial extent of the blades and the axis of rotation to permit increased tip speed for greater durability.

Description of the Prior Art: Centrifugal compressors are used in various applications for pressurizing a fluid and delivering it through an outlet passageway. A centrifugal compressor typically comprises an impeller mounted within a closely-conforming impeller chamber. The chamber has an axial, inlet port or passageway for permitting the fluid to enter the chamber adjacent the center of the impeller. The fluid is drawn into the chamber by rotation of the impeller and is delivered thereby through an annular, diffuser passageway into a surrounding volute, outlet passageway. The rotation of the impeller imparts a velocity to the particles of the fluid. The energy of the fluid represented by this velocity is converted through the medium of the diffuser

passageway into a pressure within the scroll or volute passageway.

It is generally desirable to provide a centrifugal compressor apparatus which can withstand a high rotational velocity for the compressor wheel, and at the same time a low size and weight for the apparatus. For many compressors, the velocity of the tip of the compressor blades furthest from the rotational axis can be extremely high. These extreme speeds result in a substantial stress proportional to the square of the rotational speed and reaching a maximum at the center. However, the compressor hubs have in the past been provided with a central bore within which a shaft is received for mounting the compressor wheel for rotation. This bore results in an inherent weakness of the hub which in the past has been overcome by providing a greater size to the hub to meet the strength requirements.

In certain applications a centrifugal compressor is combined with a turbine assembly such as found in a typical turbocharger. In such arrangements, the same strength requirements are typically present. In such arrangements, the turbine wheel has in some instances been formed integral with the shaft upon which the compressor wheel is mounted. An example of an integral shaft and turbine wheel is contained in United States Patent No. 2,583,430, issued to Kadenacy on January 22, 1952. This provides the desired strength for the turbine wheel, but has an increased expense associated with it.

In some instances, the turbine wheel for a turbocharger type device has been provided with a solid hub and a mounting boss which extends inwardly therefrom and is connected with the shaft. However, to applicant's knowledge there has not been provided in the prior art a compressor wheel which has a solid hub for the full axial extent of the blades. Referring, for example, to United

States Patent No. 3,874,824, issued to Cronstedt et al. on April 1, 1975, there is disclosed a turbine wheel having a shaft portion that is secured by internal threads onto the external threads of a shaft. As noted in the prior art discussion of the Cronstedt patent, the common practice for small gas turbine engines that use centrifugal and centripetal components has been to tie the compressor and turbine together by means of a threaded connection. It is stated therein that this may take the form of a threaded portion on a shaft that is integral with one of the components. The other component is then telescoped over the shaft and a nut applied to hold the components axially. In another form, one of the components may have a threaded bore and the other component is secured to the first component by means of an ordinary bolt assembly extending through a hole in the other component and received in the threaded bore. An example of the latter type of device is contained in United States Patent No. 2,938,659, issued to Judson et al. on May 31, 1960.

In United States Patent No. 3,961,867, issued to Woollenweber on June 8, 1976, there is described an assembly useful with a centrifugal compressor or the like. The Woollenweber patent shows a compressor wheel which, as in the Judson et al. patent, shows a compressor wheel which does not include a central bore but which is threaded onto the end of the shaft. As in the Judson et al. patent, the Woollenweber device does extend the bore into the hub within the area of the blades, thus having the noted disadvantage of susceptibility to stress failure.

Various other approaches have been used in the design of centrifugal compressors in general, and of turbochargers in particular. In United States Patent No. 3,778,194, issued to Miller et al. on December 11, 1973, there is described a turbine wheel which is shown to be

threaded onto the shaft. A turbine wheel having a boss received within a bore in the end of the shaft is described in United States Patent No. 2,860,827, issued to Egli on November 18, 1958. Other patents of only general interest are United States Patent Nos. 3,898,793, issued to Nakamura et al. on August 12, 1975; 2,632,596, issued to Schellens on March 24, 1953; 2,495,525, issued to Karassik on January 24, 1950; and 3,099,385, issued to Elford on July 30, 1963.

While the invention has been illustrated and described in detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

Summary of the Invention

Briefly, describing one aspect of the present invention, there is provided a centrifugal compressor apparatus which includes a bearing housing, bearing means within the housing and receiving a shaft, a compressor cover mounted to the housing and defining an impeller chamber, an impeller received within the chamber, the impeller including a hub having a solid hub for the axial extent of the blades and having a boss extending therefrom, and means for mounting the boss of the impeller to the shaft.

It is an object of the present invention to provide a centrifugal compressor which is operable at high speeds, and which has a minimal susceptibility to stress failure.

A further object of the present invention is to provide a centrifugal compressor which includes an impeller which is solid in the area of the blades to provide desired strength with a minimal size and weight.

Further objects and advantages of the present invention will be apparent from the description of the preferred embodiment which follows.

Brief Description of the Drawing

FIG. 1 is a side, cross-sectional view of a turbocharger incorporating a centrifugal compressor designed in accordance with the present invention.

Description of the Preferred Embodiment

For the purposes of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

Referring now to the figure, there is shown a turbocharger assembly 10 including a compressor 11 constructed in accordance with the present invention. The two main subassemblies of the turbocharger are the compressor 11 and turbine 12. Bearing housing assembly 13 supports and interconnects the compressor 11 and the turbine 12.

Assembly 13 includes a shaft 14 rotatably supported within bearing housing 15 by sleeve bearings 16. Turbine wheel 17 is connected to one end of shaft 14 and is received within turbine housing 18. The turbine housing is secured to bearing housing 15 by V-clamp 19. Impeller 20 is received within an impeller chamber 21 defined by the bearing housing 15 and the cover 22 secured to the housing by a clamp 23. Impeller 20 includes blades 24 extending therefrom, and is mounted to shaft 14 as is further explained below.

Exhaust gas from the exhaust manifold of an engine to which turbocharger 10 is connected enters turbine housing 18 through turbine inlet 25 and thereafter enters volute 26. The gas enters the turbine wheel 17 around its periphery and expands through exhaust outlet 27. Energy

of the exhaust gas is thereby converted to mechanical work, turning wheel 17 and driving shaft 14 and compressor wheel or impeller 20. The impeller 20 is used to compress air to increase the amount of air delivered to the engine cylinders above that available in natural aspiration. The compressed air exits compressor 11 through a tangential outlet communicating with passageway 28 and connected to the engine intake manifold or air induction system. As a result, the engine burns more fuel and produces greater power.

Compressor wheel or impeller 20 is mounted upon shaft 14 and is operable to rotate therewith. Impeller 20 includes blades 24. Compressor cover 22 is attached to bearing housing 15 and includes a wall portion 29 defining an impeller chamber 21 which closely conforms to the profile of blades 24. Cover 22 further comprises a scroll 30 defining the toroidal or volute passageway 28 which surrounds impeller chamber 21 and communicates therewith through annular diffuser passageway 31. Upon rotation of impeller 20, the air to be pressurized is drawn inwardly into impeller chamber 21 by blades 24 and is propelled through diffuser passageway 31 into the volute, outlet passageway 28.

In contrast to the prior art, the present invention provides a compressor wheel or impeller 20 which has a solid hub for the axial extent of the blades. Referring in particular to the drawings, it is shown that the impeller includes a hub 32 from which the plurality of blades 24 extend outwardly, generally radially. The impeller has a back end 33 adjacent the bearing housing and a front end 34 spaced from or opposite the bearing housing. The hub 32 also includes a central axis 35 about which the impeller rotates. The blades 24 extend in the direction of the front end of the impeller to a front plane 36 substantially normal to the central axis 35. The

blades 24 also extend in the direction of the back end of the impeller to a back plane 37 substantially normal to the central axis of the hub. As shown in the drawing, the hub 32 of the impeller 20 is solid in the area between the front and back planes, or in other words is solid in the area of the blades.

It will be appreciated that the peak stress for the rotating compressor wheel or impeller lies close to the plane of the back of the wheel, or more particularly close to the back plane of the blades. As previously discussed, the presence of a hole in the area of this plane results in a substantially decreased resistance to stress fatigue. A small hole is almost as bad as a big hole in this regard. The present invention is therefore desirable by providing an impeller which is fastened to a shaft and yet which is solid in this peak stress region.

Although certain turbine wheels have been attached in a fashion which avoided a hole in this peak stress region, this has been done typically for convenience of the fastening method, such as inertia or electron beam welds, and this has not been related to any design limitation. In contrast, the present invention overcomes an existing design limitation by providing an impeller which can tolerate increased tip speeds for a given size of impeller and hub as opposed to prior art devices.

Removal of the bore from the hub of a typical turbocharger compressor impeller reduces the maximum stress, considering both centrifugal and thermal loads, by about 35 percent. This stress reduction is advantageous in either of two ways. First, the maximum allowable tip speed can be increased by about 15 percent without compromising the durability of the impeller in applications involving frequent shaft speed cycling. This allows higher compressor boost ratios and/or higher operational altitude limits for the turbocharger.

Alternately, the allowable tip speed could be held to the currently established limit, with the expectation of at least five times the number of speed cycles prior to hub fatigue failure.

As shown in the figure, the impeller hub includes a boss 38 which extends outwardly at the back end of the impeller. This boss is mounted to the shaft 14. In the preferred embodiment shown, the hub of the impeller is tapered, such as at 39, in the direction of the back end from the back plane 37 to the boss 38. The boss may be cast integrally with the hub, or may be attached thereon such as by welding.

The boss is provided with an internally threaded bore 40, with the bore extending inwardly in the direction of the front end of the impeller but short of the back plane 37. Thus, although a bore is provided in the impeller, it is located within the boss portion 38 and therefore is spaced apart from the back plane 37 at which the maximum stress is experienced. The shaft 14 includes a reduced diameter portion 41, a circumferential groove 42 at the end of the threads, and a threaded end 43 with a pilot on the end. The threaded and piloted end 43 is received within the bore 40 and centered and secured thereby. The threads will be reverse to the rotation of the wheel. The front end of the impeller is provided with a wrench lug portion 44 to facilitate mounting of the impeller to the shaft as described.

Assembly 13 may comprise any suitable combination of bearing, lubricating and sealing elements required to rotatably support shaft 14 in the conditions of operation. The specific components of bearing housing assembly 13 do not constitute a part of the present invention, and therefore will not be recited in full detail, these components and their interrelationships being known in the art.

The exterior of the boss 38 is provided with a circumferential groove 45 in which a sealing ring 46 is received, which seals with the plate 54 secured within the bearing housing. In somewhat typical fashion, a thrust ring 47 is received against a shoulder 48 at the location of the reduced diameter portion 41 of the shaft. A spacer 49 is received against the first thrust ring 47, and a second thrust ring 50 is received against the spacer. The hub is received upon the threaded end of the shaft and tightened thereon with the back end of the boss 38 securing the thrust rings 47 and 50 and spacer 49 against the shoulder 48 of the shaft. A thrust bearing 51 is positioned between the thrust rings 47 and 50 and includes oil passageways, such as 52, to provide lubrication at the thrust surfaces. An oil deflector 53 is also provided.

WHAT IS CLAIMED IS:

1. A centrifugal compressor apparatus suitable for use with an internal combustion engine which comprises:

a bearing housing;

bearing means mounted within said bearing housing, said bearing means being for rotatably receiving a shaft;

a shaft received and rotatable within said bearing means;

a compressor cover mounted to said bearing housing and defining therewith an impeller chamber;

an impeller received within the impeller chamber, said impeller including a hub and a plurality of blades extending outwardly therefrom, said impeller having a back end adjacent said bearing housing and a front end spaced from said bearing housing, the hub having a central axis of rotation, the blades extending in the direction of the front end of said impeller to a front plane substantially normal to the central axis of the hub and in the direction of the back end of said impeller to a back plane substantially normal to the central axis of the hub, the hub of said impeller being solid in the area between the front and back planes, said impeller including a boss extending toward and defining the back end of said impeller; and

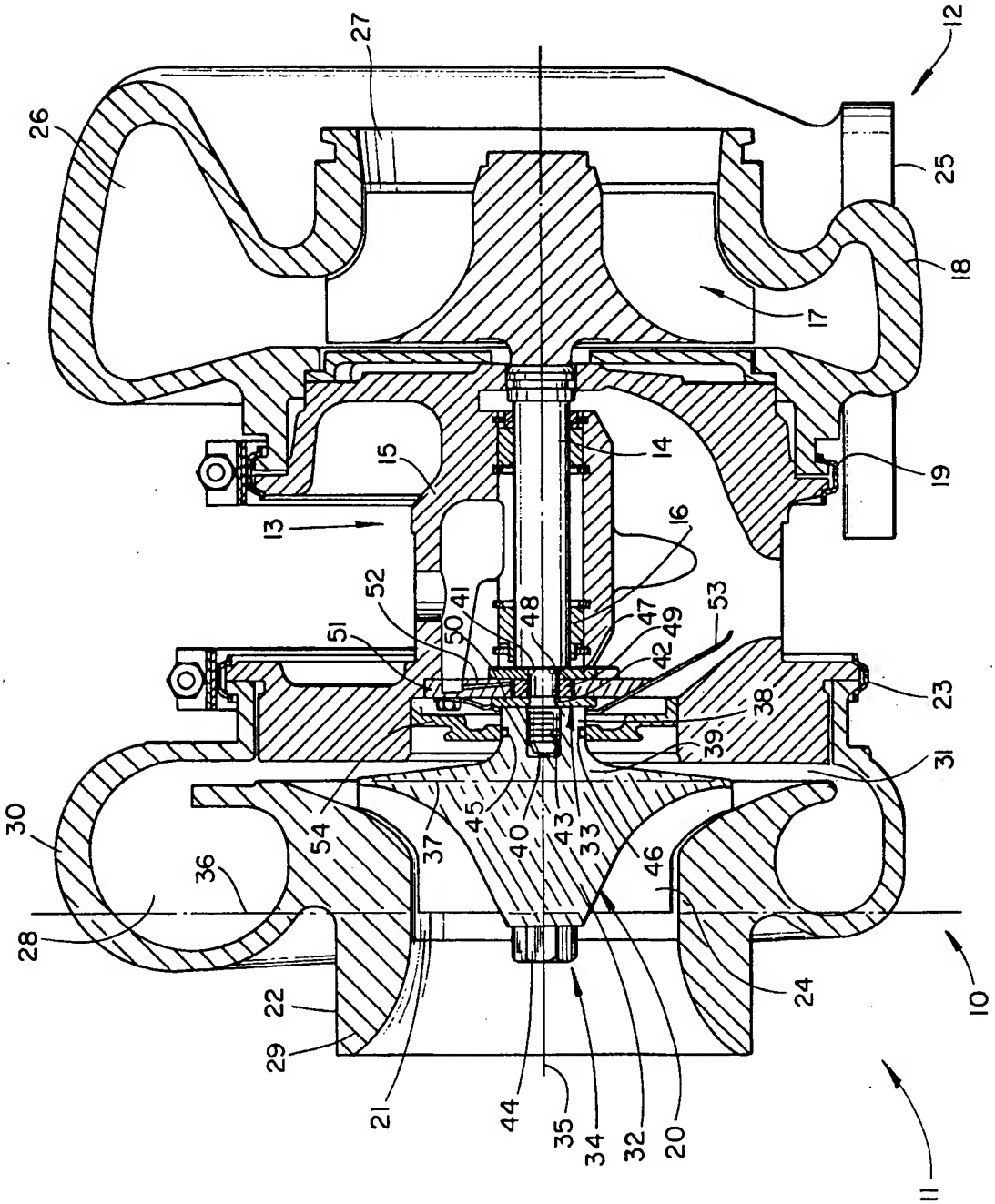
mounting means for mounting the boss of said impeller to said shaft.

2. The apparatus of claim 1 in which said mounting means includes the boss having an internally threaded bore and said shaft including an externally threaded end, the bore of said hub extending inwardly in the direction of the front end of said impeller short of the back plane, the threaded end of said shaft being received within the threaded bore of the boss.

3. The apparatus of claim 2 in which the front end of the hub of said impeller defines a wrench lug to facilitate mounting of said impeller to said shaft.

4. The apparatus of claim 1 in which the hub of said impeller is tapered inwardly in the direction of the back end from the back plane to the boss.

5. The apparatus of claim 4 in which said mounting means includes the boss having an internally threaded bore and said shaft including an externally threaded end, the bore of said hub extending inwardly in the direction of the front end of said impeller short of the back plane, the threaded end of said shaft being received within the threaded bore of the boss.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EUROPEAN SEARCH REPORT

Application number

EP 84 30 6755

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
X	US-A-3 961 867 (HOLSET ENGINEERING COMPANY LTD.) * Column 2, line 62 - column 3, line 42; column 4, lines 8-9; figures 1,2 *	1,2,5	F 04 D 29/28 F 01 D 5/06
Y		4	
Y	US-A-4 340 317 (NORTHERN RESEARCH & ENGINEERING CORP.) * Column 2, lines 30-36; figures 1,3 *	4	
A		2,5	
A	GB-A- 655 880 (THE BRITISH THOMSON-HOUSTON COMPANY LTD.) * Figure 1 *	4	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
X,E	EP-A-0 129 311 (THE GARRETT CORP.) * Page 5, lines 16-20; page 6, line 34 - page 7, line 30; page 8, line 34 - page 9, line 14; figures 3,4 *	1-5	F 01 D F 04 D

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	15-01-1985	HOEPER H.H.

CATEGORY OF CITED DOCUMENTS

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